

Appendix B

**Revised Ecological Risk Assessment – Step 3 – Refinement of Constituents of Potential
Ecological Concern and Development of Ecological Remedial Action Objectives
CRA, Revision 3, November 2014**



Ecological Risk Assessment

Step 3 Refinement of Constituents of Potential Ecological Concern and Development of Ecological Remedial Action Objectives

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Executive Summary

Conestoga-Rovers & Associates (CRA), on behalf of Weyerhaeuser NR Company (Weyerhaeuser), conducted a refinement of chemical constituents identified in the screening-level ecological risk assessment (SLERA) portion of the Remedial Investigation Report (RI Report) as constituents of potential ecological concern (COPECs) for the former Plainwell Inc., Mill Property in Plainwell, Michigan (Site). The RI Report was approved on February 26, 2013. The refinement process is Step 3 of the 8-step process for conducting ecological risk assessment under guidance developed by the United States Environmental Protection Agency (U.S. EPA).

The majority of the Site evaluated in the SLERA is anticipated to be redeveloped for residential and/or commercial use. As complete exposure pathways will be eliminated in those areas that will be developed, the dataset for the refinement process consisted of samples from those areas that will not be disturbed by development activities. The revised assessment area is within the riparian corridor of the Kalamazoo River. The data for the revised assessment were re-screened using the same methodology and ecological screening values (ESVs) that were used in the SLERA. The re-screening retained two volatile organic compounds (VOCs) (i.e., acetone and isopropylbenzene), three benzene, toluene, ethylbenzene, and xylenes (BTEX) constituents (i.e., benzene, toluene, and m&p-xylenes), one semi-volatile organic compound (SVOC) (i.e., carbazole), high molecular weight (HMW) polycyclic aromatic hydrocarbons (PAHs), total polychlorinated biphenyls (PCBs), and 14 inorganic constituents [i.e., antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, vanadium, zinc, and cyanide (total)] as COPECs.

The refinement process focused on avian and mammalian wildlife. Refinement consisted of a two-phase process. In the first phase, 95 percent upper confidence limit (UCL) concentrations of the COPECs were compared to ecological benchmarks (i.e., soil concentrations) specific to avian and/or mammalian wildlife. A constituent was carried forward to the second phase if the 95 percent UCL concentration was greater than the ecological benchmark or if an ecological benchmark was not available. This phase eliminated total PCBs, antimony, arsenic, barium, chromium, manganese, and vanadium as COPECs.

The second phase of the refinement process involved use of food chain models to assess the potential for risk to avian and mammalian wildlife. The food chain models identified a potential for risk to avian insectivores exposed to lead at both a no observed adverse effect level (NOAEL) and lowest observed adverse effect level (LOAEL), and mammalian wildlife exposed to lead at the LOAEL. The food chain models also identified a potential for risk to avian and/or

mammalian wildlife exposed to carbazole, HMW PAHs, cadmium, copper, mercury, selenium, and zinc at the NOAEL, but not the LOAEL.

Ecological preliminary remediation goals (PRGs) were developed for carbazole, HMW PAHs, cadmium, copper, lead, mercury, selenium, and zinc. The ecological PRGs were the lowest of the PRGs for avian and mammalian wildlife. The ecological PRGs were compared to the 95 percent UCL concentrations of the COPECs. The 95 percent UCL concentrations for carbazole, HMW PAHs, cadmium, copper, lead, mercury, selenium, and zinc were below their ecological PRGs. The 95 percent UCL concentrations for these seven COEPCS were also less than 50 percent of the PRGs for all COPECs. Due to the uncertainty associated with the LOAEL for avian wildlife, lower and upper PRGs were developed for lead. The 95 percent UCL concentration for lead was above the lower end PRG and below the upper end PRG. Removal of the maximum concentration of lead from the dataset produces a 95 percent UCL below the lower end PRG.

The ecological PRGs are 0.672 milligrams per kilogram (mg/kg) for carbazole, 59.6 mg/kg for HMW PAHs, 2.01 mg/kg for cadmium, 634 mg/kg for copper, 140 mg/kg (lower end) and 812 mg/kg (upper end) for lead, 3.19 mg/kg for mercury, 9.09 mg/kg for selenium, and 1,705 mg/kg for zinc. The data and analyses presented in this document are sufficient for decisions to be made regarding the protection of ecological receptors within the corridor of the Kalamazoo River. Consequently, the ecological risk assessment process is not advancing to the next steps of the BERA.

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List of Acronyms and Abbreviations

BCOC	Bioaccumulative Chemical of Concern
BERA	Baseline Ecological Risk Assessment
bgs	Below Ground Surface
BW	Body Weight
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CCME	Canadian Council of Ministers of the Environment
Conc _{food}	Concentration of a Chemical Constituent in Food
Conc _{soil}	Concentration of a Chemical Constituent in Soil
Conc _{water}	Concentration of a Chemical Constituent in Water
COPEC	Constituent of Potential Ecological Concern
CRA	Conestoga-Rovers & Associates
CSM	Conceptual Site Model
DW	Dry Weight
ECO-SSL	Ecological Soil Screening Level
ESL	Ecological Screening Level
ESV	Ecological Screening Value
FOD	Frequency of Detection
g	gram
HMW	High Molecular Weight
HQ	Hazard Quotient
HQ _{LOAEL}	Hazard Quotient Based on the Lowest Observed Adverse Effect Level
HQ _{NOAEL}	Hazard Quotient Based on the No Observed Adverse Effect Level
IR _{food}	Ingestion Rate of Food
IR _{total}	Total Ingestion Rate of a Chemical Constituent
IR _{water}	Ingestion Rate of Water
IRIS	Integrated Risk Information System
kcal	kilocalories
kg	kilogram
K _{OW}	Octanol-Water Partition Coefficient
L	Liter
LMW	Low Molecular Weight
LOAEL	Lowest Observed Adverse Effect Level
LOD	Limit of Detection
MDEQ	Michigan Department of Environmental Quality
mg	milligram
NOAEL	No Observed Adverse Effect Level
OSWER	Office of Solid Waste and Emergency Response
P _s	Proportion of Soil Ingested
PCB	Polychlorinated Biphenyl

List of Acronyms and Abbreviations (continued)

PAH	Polycyclic Aromatic Hydrocarbon
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
RB	Refinement Benchmark
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RQ	Refinement Quotient
RQ _{UCL}	Refinement Quotient Based on the 95% Upper Confidence Limit
SLERA	Screening-Level Ecological Risk Assessment
SQ	Screening Quotient
SQG _E	Soil Quality Guideline-Environment
SVOC	Semi-Volatile Organic Compound
TRV	Toxicity Reference Value
UCL	Upper Confidence Limit
µg	microgram
U.S. EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WSB	Wildlife Scenario Builder

Section 1.0 Introduction

Conestoga-Rovers & Associates (CRA), on behalf of Weyerhaeuser NR Company (Weyerhaeuser), conducted a Remedial Investigation (RI) at the former Plainwell Inc., Mill property in Plainwell, Michigan (Site). The RI Report was submitted to the United States Environmental Protection Agency (U.S. EPA) on June 20, 2011, with revisions submitted on April 20, 2012 (Revision 1), July 10, 2012 (Revision 1), October 19, 2012 (Revision 2), and February 4, 2013 (Revision 2), respectively, based on comments received from and discussions with representatives of the U.S. EPA and the Michigan Department of Environmental Quality (MDEQ). The RI Report was approved by the U.S. EPA on February 26, 2013.

A screening-level ecological risk assessment (SLERA) was included as a component of the RI. The SLERA consisted of Steps 1 and 2 of the 8-step process for conducting ecological risk assessment in accordance with guidance published by the United States Environmental Protection Agency (U.S. EPA, 1997). The SLERA identified 42 individual chemical constituents or constituent groups as constituents of potential ecological concern (COPECs). The methods and assumptions used in the SLERA were intentionally conservative in order to minimize the probability of incorrectly eliminating constituents that may actually pose risk to ecological receptors. Consequently, not all of the individual constituents or constituent groups are expected to pose an unacceptable potential for risk.

This document represents the next step in the 8-step process. In this step, which is Step 3, or the problem formulation for the baseline ecological risk assessment (BERA), the constituents identified in the SLERA as COPECs are refined by evaluating the assumptions for exposure and toxicological responses of ecological receptors to the COPECs. The primary objective of the refinement process is to eliminate from further consideration those constituents that have a limited potential for risk so the BERA can focus on those constituents and pathways that have the greatest potential to pose risk.

The majority of the Site evaluated for the SLERA will ultimately be redeveloped for residential, commercial, and mixed residential and commercial land use. Consequently, ecological receptors will not be exposed to those areas that will be developed. The dataset for the refinement process has been modified to include only samples from those areas that are unlikely to be disturbed by development activities. These samples are located within the riparian corridor of the Kalamazoo River, as shown on Figure 1.1.

The remainder of this report is organized as follows:

- Section 2.0 – summarizes the results of the SLERA
- Section 3.0 – provides a general description of the methodology for the refinement process
- Section 4.0 – presents the results of re-screening of the revised dataset
- Section 5.0 – provides additional details and results of the refinement process
- Section 6.0 - discusses uncertainties associated with the refinement process
- Section 7.0 – describes the methodology and presents results for development of ecological preliminary remediation goals (PRGs)
- Section 8.0 – identifies complete exposure pathways and ecosystems at risk
- Section 9.0 – identifies assessment endpoints for the BERA
- Section 10.0 – presents the conceptual site model and risk questions for the BERA
- Section 11.0 – presents summary and conclusions of the refinement process
- Section 12.0 – provides citations for references

Section 2.0 Summary of the Screening-Level Ecological Risk Assessment

2.1 Constituents of Potential Ecological Concern

The SLERA, which was submitted as part of the RI report, identified a total of 42 individual or groups of chemical constituents as COPECs. A constituent was identified as a COPEC if:

- The maximum concentration exceeded an ecological screening value (ESV)
- The constituent was detected and an ESV was not identified
- The constituent was not detected and the limit of detection (LOD) is greater than 20 percent of the samples exceeded an ESV
- The constituent was detected and was identified as a bioaccumulative chemical of concern (BCOC)

Table 2.1 summarizes the constituents and groups of constituents identified in the SLERA as COPECs and the basis upon which each was identified as a COPEC.

In order to minimize the potential for incorrectly eliminating a constituent as a COPEC, the SLERA employed a number of conservation assumptions. In Step 3 of the process, those assumptions are evaluated and, as appropriate, replaced with more ecological realistic assumptions with the overall objective of refining the list of COPECs identified in Table 2.1 to those with the greatest potential for posing risk to ecological receptors.

2.2 Assessment Endpoints

Assessment endpoints are explicit expressions of environmental values or characteristics to be protected at a site, and reflect societal and ecological values (Suter, 1993). Societal values address the need to protect species that are endangered, threatened, or of special interest, important as game or commercial species, or that are recognized as having aesthetic value. The assessment endpoints for the SLERA were species richness and productivity of terrestrial plant and soil invertebrate communities, and the relative and absolute densities of avian and mammalian insectivores, herbivores, omnivores, and carnivores.

The refinement process presented in this document focuses on the assessment endpoints associated with avian and mammalian wildlife. The rationale for this focus is that the methods and exposure factors for evaluating potential for wildlife are better developed and have a stronger technical basis than those available for terrestrial plants and soil invertebrates. As an example, the vast majority of studies used to evaluate risk to terrestrial plants have been conducted using common agricultural crops. These "species" are typically annuals that have been artificially selected for yield over many generations and, as a result, lack the genetic diversity characteristic of naturally occurring species. Furthermore, observations of the assessment area during numerous sampling events and other field activities have not identified significant areas of stressed vegetation.

2.3 Measurement Endpoints

Data necessary to directly evaluate the assessment endpoints are difficult to generate and rarely available. Therefore, measurement endpoints are used to bridge this gap. Measurement endpoints are quantifiable responses to stressors related to assessment endpoints, and are intended to provide a basis for assessing risk potential for the assessment endpoint. They may be defined in terms of an unacceptable level of impact to ecological receptors, such as a certain relative percent decrease in survival, growth or reproduction of ecological populations (Suter, 1993).

For the refinement process, two types of measurement endpoints are considered. One type consists of ecological benchmarks, or concentrations, that have been developed specifically to assess the potential for risk to avian and/or mammalian wildlife. The second type of measurement endpoints are toxicity reference values (TRVs), which are expressed as milligrams of a chemical ingested per body weight of a receptor per day (mg/kg/day). A no observed adverse effect level (NOAEL) is a TRV below which adverse effects on growth, reproduction, and/or survival are not expected to be expressed. A lowest observed adverse effect level (LOAEL) is the lowest TRV at which adverse effects have been documented to occur.

Section 3.0 Refinement Methodology

3.1 Dataset

The dataset evaluated in the SLERA consisted of all samples of surface soil collected within the assessment area. Surface soil is considered to be that collected from the depth interval of 0 to 2 feet below ground surface (bgs). The Site was partitioned into 11 redevelopment areas, with each area evaluated as a separate sub-area. For the refinement process, those areas that will ultimately be developed for residential, commercial, and mixed land use have been removed from the dataset. Development of these areas will result in an incomplete exposure pathway. Samples from those locations that are not likely to be disturbed by redevelopment activities and that provide habitat for ecological receptors have been retained. These samples are located along the riparian corridor of the Kalamazoo River. The riparian corridor of the Kalamazoo River was evaluated as a single assessment area.

Figure 1.1 identifies the locations of the samples retained for the refinement process. Appendix A presents the analytical data associated with those sample locations used for the refinement process.

3.2 Re-Screening for Constituents of Potential Ecological Concern

The dataset for the SLERA had a total of 250 samples. The dataset for the refinement process consists of 30 samples. As many of the constituents identified in the SLERA as COPECs were detected in only one or a few samples, the first step in the refinement process was to re-screen those constituents identified in the SLERA as COPECs and were detected in one or more samples in the revised dataset. The ESVs used in the SLERA were also used for the re-screening. The maximum concentration of a COPEC was divided by its ESV to produce a screening quotient (SQ). A constituent was retained as a COPEC if the maximum concentration exceeded its ESV ($SQ > 1.0$), or the constituent was detected and an ESV was not identified.

The refinement process did not consider those constituents that were not detected as they are not expected to be the primary drivers of risk to ecological receptors.

3.3 Avian and Mammalian Wildlife

Assessment of risk to avian and mammalian wildlife in the refinement process was conducted using a two-phase approach. In the first phase, the 95 percent upper confidence limit (UCL) concentrations for the COPECs were compared to ecological benchmarks specific to avian and/or mammalian wildlife, if available. The 95 percent UCL were selected as the exposure concentrations as they represent reasonable maximum exposure (RME) to receptors that

forage at numerous locations within the assessment area. The 95 percent UCLs were calculated using ProUCL, Version 5.0 (U.S. EPA, 2013a).

Sources of benchmarks for avian and mammalian wildlife were the source documents for the ecological soil screening levels (ECO-SSLs), Efroymson et al. (1997a), and fact sheets prepared by the Canadian Council of Ministers of the Environment (CCME). For mammalian wildlife, ecological screening levels (ESLs) identified by U.S. EPA, Region 5 (2003) were used if an ESL was based on masked shrew or meadow vole. Benchmarks for the refinement process were selected using the following hierarchy:

- ECO-SSLs were the first tier of the hierarchy for both avian and mammalian wildlife
- n wildlife and third tier benchmarks for mammalian wildlife
- For mammalian wildlife, ESLs based on the masked shrew or meadow vole, were the second tier of the hierarchy if an ECO-SSL was not available
- PRGs identified by Efroymson et al. (1997a) were the second tier benchmarks for avia
- Soil quality guidelines (SQG_E) for agricultural land use developed by CCME were the third tier benchmarks for avian wildlife and fourth tier benchmarks for mammalian wildlife

If the 95 percent UCL concentration of a constituent was greater than benchmarks specific to avian and/or mammalian wildlife, the constituent was carried forward to the second phase of the assessment. This second phase consisted of the use of food chain models to further evaluate the potential for risk. Section 5.2.1 provides details for the use of food chain models.

Section 4.0 Re-Screening of the Dataset for the Refinement Process

Table 4.1 summarizes the results of the re-screening of the data for the refinement process. Information presented in Table 4.1 includes the ESV and source of the ESV, or lack thereof, for each constituent detected; the number of samples, number of samples with detected concentrations, and frequency of detection (FOD); maximum concentration and area and sample with the maximum concentration; SQ; identification of bioaccumulative chemicals of concern (BCOCs); retention of a constituent as a COPEC; and rationale for retaining or eliminating a constituent as a COPEC.

Two volatile organic compounds (VOCs), acetone and isopropylbenzene, were detected. The SQ for acetone (2.2) is greater than 1.0. An ESV was not identified for isopropylbenzene. Accordingly, both acetone and isopropylbenzene are retained as COPECs.

Four BTEX (benzene, toluene, ethylbenzene, and xylenes) constituents were detected. The SQs for benzene (5.1), toluene (4.0), and m&p-xylene (1.1) are greater than 1.0. These three constituents are retained as COPECs. The SQ for o-xylene (0.74) is less than 1.0. Consequently, o-xylene is eliminated as a COPEC.

Two semi-volatile organic compounds (SVOCs), bis(2-ethylhexyl)phthalate and carbazole, were detected. The SQ for bis(2-ethylhexyl)phthalate (0.38) is less than 1.0. An ESV was not identified for carbazole. Accordingly, bis(2-ethylhexyl)phthalate is eliminated as a COPEC and carbazole is retained.

The SLERA identified high molecular weight (HMW) polycyclic aromatic hydrocarbons (PAHs) as a COPEC. For the revised dataset, the SQ (24) for HMW PAHs [benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, and pyrene] is greater than 1.0. Based on this SQ, all HMW PAHs are retained as COPECs.

Three Aroclors of polychlorinated biphenyls (PCBs) were detected. The three Aroclors are Aroclor-1248, Aroclor-1254, and Aroclor-1260. Similar to PAHs, PCBs are evaluated as a group. For the revised dataset, the SQ for total PCBs (1,205) is greater than 1.0. Consequently, total PCBs, which are BCOCs, are retained as a COPEC.

Sixteen inorganic constituents identified as COPECs in the SLERA were detected. The SQs for cobalt (0.59) and nickel (0.77) are less than 1.0. Nickel is a BCOC. Although the ESV for nickel (38 mg/kg) is based on plants, it is lower than the ECO-SSLs for avian (210 mg/kg) and mammalian (130 mg/kg) wildlife (U.S. EPA, 2007d). Cobalt and nickel are eliminated as COPECs.

The SQs for antimony (11), arsenic (1.2), barium (1.5), cadmium (11), chromium (1.5), copper (11), iron (111), lead (90), manganese (3.2), mercury (56), selenium (3.5), vanadium (3.6), zinc (17), and cyanide (total) (1.3) are greater than 1.0. Iron is a naturally occurring metal with limited toxicity to ecological receptors (U.S. EPA, 2003a), and is eliminated as a COPEC. Antimony, arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, selenium, vanadium, zinc, and cyanide (total) are retained as COPECs. Cadmium, chromium, copper, lead, mercury, selenium, and zinc are BCOCs.

Section 5.0 Refinement of Constituents of Potential Ecological Concern

5.1 Comparison to Wildlife Benchmarks

5.1.1 Avian Wildlife

Table 5.1 identifies the available benchmarks for avian wildlife. Information presented in Table 5.1 includes benchmark concentrations identified in ECO-SSL source documents (U.S. EPA 2005a-d,f, 2007b,f-g, 2008), Efroymson et al. (1997a), and CCME (1999a-f, 2001, 2009, 2010) as well as background concentrations specific to the Michigan Glacial Lobe identified by the MDEQ (MDEQ, 2005) and specific to Michigan identified by U.S. EPA (2007a). Table 5.1 also identifies the value selected as the refinement benchmark (RB).

Background concentrations were considered in the selection of RBs. Priority in the selection of RBs was given to the ECO-SSLs developed by U.S. EPA. If an ECO-SSL was not available, RBs were selected using the hierarchy discussed in Section 3.3, with the following exceptions. The ECO-SSL for cadmium is 0.77 mg/kg, which is below the background concentration of 0.90 mg/kg identified by U.S. EPA (2007a). Similarly, the ECO-SSL for vanadium of 7.8 mg/kg is below the background concentration of 44 mg/kg. An ecological benchmark specific to avian wildlife is not available for antimony. For these three metals, background concentrations were selected as the RBs.

Table 5.2 summarizes the first phase of refinement for avian wildlife. Information presented in Table 5.2 includes the RB, number of samples, number of samples with detected concentrations, the minimum and maximum detected concentrations, 95 percent UCLs, the refinement quotients ($RQ_{UCL} = 95 \text{ percent UCL concentration divided by the RB}$), and rationale for retaining or eliminating a constituent as a COPEC.

Refinement benchmarks are not available for acetone, isopropylbenzene, benzene, toluene, xylenes (total), and carbazole. These six organic compounds are retained as COPECs.

The RQ_{UCL} s for HMW PAHs (23), cadmium (1.1), copper (5.1), lead (16), mercury (2,990), and zinc (7.2) are greater than 1.0. These six constituents are retained as COPECs and carried forward for further evaluation using food chain models.

The RQ_{UCL} s for total PCBs (0.29), antimony (0.73), arsenic (0.25), barium (0.60), chromium (0.64), manganese (0.11), selenium (0.62), vanadium (0.41), and cyanide (total)(0.13) are less than 1.0. These nine constituents are eliminated as COPECs for avian wildlife.

5.1.2 Mammalian Wildlife

Table 5.3 identifies the available benchmarks for mammalian wildlife. Information presented in Table 5.3 is similar to that presented in Table 5.1 for avian wildlife. The sources of ecological benchmarks for mammalian wildlife are the same as those for avian wildlife, with the addition of the U.S. EPA, Region 5 ESLs that are based on masked shrew or meadow vole (U.S. EPA, 2003).

As was done for avian wildlife, background concentrations were considered in the selection of RBs for mammalian wildlife. Priority in the selection of RBs was given to the ECO-SSLs developed by U.S. EPA. If an ECO-SSL was not available, RBs were selected using the hierarchy discussed in Section 3.3, with the following exceptions. The ECO-SSL of 0.27 mg/kg and ESL of 0.142 mg/kg for antimony are below the mean background concentration of 1.3 mg/kg identified by U.S. EPA (2007a). The ECO-SSL of 0.36 mg/kg and ESL of 0.0022 mg/kg for cadmium are also below the mean background concentration of 0.90 mg/kg. The mean background concentrations were selected as the RBs for antimony and cadmium.

Table 5.4 summarizes the first phase of refinement for mammalian wildlife. Information presented in Table 5.4 is similar to that presented in Table 5.2 for avian wildlife.

Refinement benchmarks are not available for isopropylbenzene, xylenes (total), and carbazole. These three organic compounds are retained as COPECs.

The RQ_{UCLs} for acetone (2.2), HMW PAHs (13), cadmium (1.1), copper (2.9), lead (3.2), mercury (10), selenium (1.2), zinc (4.2), and cyanide (total) (1.1) are greater than 1.0. These nine constituents are retained as COPECs and carried forward for further evaluation using food chain models.

The RQ_{UCLs} for benzene (0.65), toluene (0.49), total PCBs (0.14), antimony (0.73), arsenic (0.24), barium (0.085), chromium (0.49), manganese (0.12), and vanadium (0.065) are less than 1.0. These nine constituents are eliminated as COPECs for mammalian wildlife.

5.2 Food Chain Models

5.2.1 Overview

Six species were selected as indicator species for avian and mammalian insectivores, herbivores, and carnivores. American woodcock and short-tailed shrew were selected as the indicator species for avian and mammalian insectivores, respectively. Mourning dove and meadow vole were selected as the indicator species for avian and mammalian herbivores,

respectively. Red-tailed hawk and long-tailed weasel were selected as the indicator species for avian and mammalian carnivores, respectively. The six indicator species were selected based on their use by U.S. EPA to develop the ECO-SSLs for avian and mammalian wildlife (U.S. EPA, 2007a).

For each indicator species, total ingestion of a COPEC was calculated using the general equation:

$$IR_{\text{total}} = (IR_{\text{food}} * \text{Conc}_{\text{food}}) + (IR_{\text{water}} * \text{Conc}_{\text{water}}) + (P_S * IR_{\text{food}} * \text{Conc}_{\text{soil}}) \quad \text{Equation 1}$$

Where:

IR_{total} = Total ingestion rate of a COPEC (mg of COPEC per kg body weight per day)
IR_{food} = Ingestion rate of food (kg of food [dry weight] per kg body weight per day)
IR_{water} = Ingestion rate of drinking water (liter per kg body weight per day)
P_S = Proportion of IR_{food} that is soil (incidental soil ingestion)
Conc_{food} = Concentration of a COPEC in food (mg of COPEC per kg [dry weight] of food)
Conc_{water} = Concentration of a COPEC in drinking water (mg of COPEC per liter)
Conc_{soil} = Concentration of a COPEC in soil (mg of COPEC per kg [dry weight] of soil)

The calculated IR_{total} for each COPEC was divided by a TRV (NOAEL and/or LOAEL) specific to the COPEC to produce a hazard quotient (HQ). A HQ greater than 1.0 identifies a potential for risk.

Table 5.5 and Table 5.6 identify IR_{food}, IR_{water}, and P_S for the avian and mammalian indicator species, respectively. The values for IR_{food} and P_S are from U.S. EPA (2007a). The values for IR_{water} are from U.S. EPA (1999a). Tables 5.5 and 5.6 also identify the diets of the indicator species. The food chain models assumed that all food consumed by all indicator species is obtained from the assessment area. Bioavailability of all COPECs evaluated was conservatively assumed to be 100 percent.

Concentrations of the COPECs in soil invertebrates, terrestrial plants, and small mammals consumed by the indicator species were calculated using general equations available in the risk assessment literature. Sources of the equations were U.S. EPA (1999b, 2007a) and Sample et al. (1998). Table 5.7 identifies the equations for each dietary item and COPEC, as well as the source. If available, equations used to develop the ECO-SSLs (U.S. EPA, 2007a) were used.

For organic compounds with a log water-octanol partitioning coefficient (log K_{ow}) less than 3.5 [acetone and xylenes (total)], soil-to-invertebrate and soil-to-plant bioaccumulation was assumed to be negligible (U.S. EPA, 2000). For organic compounds with a log K_{ow} greater than 3.5 (isopropylbenzene and carbazole), equations identified in U.S. EPA (1999b) were used to

calculate concentrations in soil invertebrates and terrestrial plants. Equations for soil-to-small mammals are not available for several COPECs. For these COPECs, concentrations in small mammals were assumed to be the higher of the concentrations in soil invertebrates and plants. Concentrations in all dietary items were calculated on a dry weight (DW) basis.

Table 5.8 identifies the exposure concentrations for soil invertebrates, terrestrial plants, and small mammals as calculated using the equations identified in Table 5.7. The 95 percent UCL concentrations in soil, calculated using ProUCL, Version 5.0 (U.S. EPA, 2013a), were used to calculate exposure concentrations in dietary items. As there are no open water bodies within the assessment area (the Kalamazoo River is outside the assessment area), concentrations of COPECs in drinking water were assumed to be negligible.

Table 5.9 identifies the TRVs (NOAELs and LOAELs) for avian and mammalian wildlife. The values for acetone, HMW PAHs, cadmium, copper, lead, mercury, selenium, and zinc were submitted to U.S. EPA Region 5, and subsequently approved, in a Technical Memorandum dated October 19, 2012 (CRA, 2012). The NOAELs and/or LOAELs for benzene, toluene, xylenes (total), and cyanide (total) are from Sample et al. (1996). The TRVs for isopropylbenzene were developed based on studies identified in the U.S. EPA's Integrated Risk Information System (IRIS) database. The TRVs for carbazole were developed based on studies identified in the National Library of Medicine's TOXNET database. Table 5.9 also identifies the source of each TRV.

TRVs for avian receptors were not identified for isopropylbenzene, benzene, toluene, xylenes (total), and carbazole. As TRVs for these constituents are available for mammalian wildlife, evaluation of risk to wildlife will be based on the food chain models for mammalian wildlife.

5.2.2 Avian Wildlife

American Woodcock

Table 5.10 summarizes the results of the food chain model for American woodcock, the indicator species for avian insectivores. Information presented in Table 5.10 includes ingestion of a COPEC via food and soil, total ingestion, the NOAEL and HQ based on the NOAEL (HQ_{NOAEL}), LOAEL and HQ based on the LOAEL (HQ_{LOAEL}), and if the constituent is carried forward for development of a Site-specific ecological PRG. A constituent was carried forward for development of a PRG if the HQ_{NOAEL} was greater than 1.0.

The HQ_{NOAEL} for acetone (0.037) is below 1.0. Based on this result, it can be concluded that acetone does not pose a potential for risk to avian insectivores above the threshold for concern and; therefore, calculation of a Site-specific PRG is not required.

For HMW PAHs, cadmium, copper, mercury, and zinc, the HQ_{NOAEL} s are greater than 1.0, whereas the HQ_{LOAEL} s are less than 1.0. The HQ_{NOAEL} s are 5.9 for HMW PAHs, 2.5 for cadmium, 9.0 for copper, 3.4 for mercury, and 7.8 for zinc, respectively. The HQ_{LOAEL} s are 0.59 for HMW PAHs, 0.17 for cadmium, 0.40 for copper, 0.73 for mercury, and 0.78 for zinc, respectively. For lead, both the HQ_{NOAEL} (1,269) and HQ_{LOAEL} (2.0) are greater than 1.0. HMW PAHs, cadmium, copper, lead, mercury, and zinc are carried forward for development of Site-specific PRGs for avian wildlife.

Mourning Dove

Table 5.11 summarizes the results of the food chain model for mourning dove, the indicator species for avian herbivores. Information presented in Table 5.11 is similar to that presented in Table 5.10 for American woodcock.

The HQ_{NOAEL} s for acetone (0.028), HMW PAHs (0.56), and cadmium (0.20) are below 1.0. Based on these results, it can be concluded that acetone, HMW PAHs, and cadmium do not pose a potential for risk to avian herbivores above the threshold for concern and; therefore, calculation of Site-specific PRGs is not required.

For copper, lead, mercury, and zinc, the HQ_{NOAEL} is greater than 1.0, whereas the HQ_{LOAEL} is less than 1.0. The HQ_{NOAEL} s are 2.8 for copper, 408 for lead, 1.3 for mercury, and 1.8 for zinc, respectively. The HQ_{LOAEL} s are 0.12 for copper, 0.65 for lead, 0.29 for mercury, and 0.18 for zinc, respectively. Copper, lead, mercury, and zinc are carried forward for development of Site-specific PRGs for avian wildlife.

Red-Tailed Hawk

Table 5.12 summarizes the results of the food chain model for red-tailed hawk, the indicator species for avian carnivores. Information presented in Table 5.12 is similar to that presented in Table 5.10 for American woodcock and Table 5.11 for mourning dove.

The HQ_{NOAEL} s for acetone (0.002), HMW PAHs (0.020), cadmium (0.017), copper (0.37), mercury (0.15), and zinc (0.28) are below 1.0. Based on these results, it can be concluded that acetone, HMW PAHs, cadmium, copper, mercury, and zinc do not pose a potential for risk to avian carnivores above the threshold for concern and; therefore, calculation of Site-specific PRGs is not required.

For lead, the HQ_{NOAEL} (53) is greater than 1.0, whereas the HQ_{LOAEL} (0.085) is less than 1.0. Lead is carried forward for development of a Site-specific PRG for avian wildlife.

5.2.3 Mammalian Wildlife

Short-Tailed Shrew

Table 5.13 summarizes the results of the food chain model for short-tailed shrew, the indicator species for mammalian insectivores. Information presented in Table 5.13 includes ingestion of a COPEC via food and soil, total ingestion, the NOAEL and HQ_{NOAEL} , LOAEL and HQ_{LOAEL} , and if the constituent is carried forward for development of a Site-specific ecological PRG. A constituent was carried forward for development of a PRG if the HQ_{NOAEL} was greater than 1.0.

The HQ_{NOAELS} for acetone (0.003), isopropylbenzene (0.086), xylenes (total) (0.007), and cyanide (total) (0.030) are below 1.0. Based on these results, it can be concluded that acetone, isopropylbenzene, xylenes (total), and cyanide (total) do not pose a potential for risk to mammalian insectivores above the threshold for concern and; therefore, calculation of Site-specific PRGs.

For carbazole, HMW PAHs, cadmium, copper, lead, mercury, selenium, and zinc, the HQ_{NOAELS} are greater than 1.0, whereas the HQ_{LOAELS} are less than 1.0. The HQ_{NOAELS} are 1.6 for carbazole, 18 for HMW PAHs, 28 for cadmium, 6.1 for copper, 12 for lead, 3.2 for mercury, 3.2 for selenium, and 13 for zinc, respectively. The HQ_{LOAELS} are 0.14 for carbazole, 0.38 for HMW PAHs, 0.026 for cadmium, 0.026 for copper, 0.051 for lead, 0.022 for mercury, 0.13 for selenium, and 0.30 for zinc, respectively. Carbazole, HMW PAHs, cadmium, copper, lead, mercury, selenium, and zinc are carried forward for development of Site-specific PRGs for avian wildlife.

Meadow Vole

Table 5.14 summarizes the results of the food chain model for meadow vole, the indicator species for mammalian herbivores. Information presented in Table 5.14 is similar to that presented in Table 5.13 for short-tailed shrew.

The HQ_{NOAELS} for acetone (0.002), isopropylbenzene (0.00003), xylenes (total) (0.003), carbazole (0.0004), HMW PAHs (0.53), cadmium (0.93), copper (0.60), lead (0.94), mercury (0.34), selenium (0.68), and cyanide (total) (0.002) are below 1.0. Based on these results, it can be concluded that acetone, isopropylbenzene, xylenes (total), carbazole, HMW PAHs, cadmium, copper, lead, mercury, selenium, and cyanide (total) do not pose a potential for risk to mammalian herbivores above the threshold for concern and; therefore, calculation of Site-specific PRGs is not required.

For zinc, the HQ_{NOAEL} (1.2) is greater than 1.0, whereas the HQ_{LOAEL} (0.028) is less than 1.0. Zinc is carried forward for development of a Site-specific PRG for mammalian wildlife.

Long-Tailed Weasel

Table 5.15 summarizes the results of the food chain model for long-tailed weasel, the indicator species for mammalian carnivores. Information presented in Table 5.15 is similar to that presented in Table 5.13 for short-tailed shrew and Table 5.14 for meadow vole.

The HQ_{NOAELS} for acetone (0.003), isopropylbenzene (0.054), xylenes (total) (0.006), carbazole (0.99), HMW PAHs (0.18), cadmium (0.69), mercury (0.72), and cyanide (total) (0.019) are below 1.0. Based on these results, it can be concluded that acetone, isopropylbenzene, xylenes (total), carbazole, HMW PAHs, cadmium, mercury, and cyanide (total) do not pose a potential for risk to mammalian carnivores above the threshold for concern and; therefore, calculation of Site-specific PRGs is not required.

For copper, lead, selenium, and zinc, the HQ_{NOAELS} are greater than 1.0, whereas the HQ_{LOAELS} are less than 1.0. The HQ_{NOAELS} are 1.1 for copper, 2.4 for lead, 1.6 for mercury, and 1.8 for zinc, respectively. The HQ_{LOAELS} are 0.005 for copper, 0.010 for lead, 0.067 for mercury, and 0.042 for zinc, respectively. Copper, lead, selenium, and zinc are carried forward for development of Site-specific PRGs for mammalian wildlife.

5.3 Summary of Food Chain Models

The food chain models identified a potential for risk due to exposure to the following COPECs in soil:

- carbazole (mammalian insectivores)
- HMW PAHs (avian and mammalian insectivores)
- cadmium (avian and mammalian insectivores)
- copper (avian insectivores and herbivores; mammalian insectivores and carnivores)
- lead (avian insectivores, herbivores, and carnivores; mammalian insectivores and carnivores)
- mercury (avian insectivores and herbivores; mammalian insectivores)
- selenium (mammalian insectivores and carnivores)
- zinc (avian insectivores and herbivores; mammalian insectivores, herbivores, and carnivores)

Risk to the receptor groups exposed to the COPECs identified above is conservatively based on HQ_{NOAELS} greater than 1. The only HQ_{LOAEL} greater than 1.0 is for avian insectivores exposed to

lead ($HQ_{LOAEL} = 2.0$). To facilitate risk management decisions, Site-specific ecological PRGs were calculated for carbazole, HMW PAHs, cadmium, copper, lead, mercury, selenium, and zinc. The methodology and values for the ecological PRGs are presented in Section 7.0.

Section 6.0 Analysis of Uncertainties

Evaluation of risk to ecological receptors is typically associated with several areas of uncertainty. In the absence of data, assumptions must be made regarding exposure concentrations and responses of ecological receptors to COPECs. To avoid incorrectly dismissing the potential for risk, exposure concentrations and other assumptions are intentionally biased toward identifying risk. As a result of this bias, it can be concluded with a high level of certainty that chemical constituents with RQs and HQs below 1.0 do not pose an unacceptable potential for risk to ecological receptors. However, a RQ or HQ greater than 1.0 does not necessarily demonstrate that the risk actually exists; only that additional evaluation should be undertaken.

One major area of uncertainty is the actual concentration of COPECs in prey items consumed by avian and mammalian wildlife. Concentrations of COPECs were estimated for soil invertebrates, plants, and small mammals using equations identified in various guidance documents (U.S. EPA, 1999b, 2007a; Sample et al., 1998). Equations for soil-to-mammal uptake were not available for several COPECs. For these COPECs, concentrations in small mammals were assumed to be the higher of the concentrations in invertebrates and plants. For organic compounds with a log K_{ow} less than 3.5, bioaccumulation was assumed to be negligible. The uncertainty of actual concentrations in the tissue of prey items could be significantly reduced by collecting and conducting chemical analysis of potential prey items.

Bioavailability of all COPECs was conservatively assumed to be 100 percent. The actual bioavailability of the chemicals evaluated is unknown, but is likely less than 100 percent. Accounting for bioavailability of the COPECs in food items and soil would reduce the HQs.

Indicator species were selected to represent the various trophic guilds evaluated in this risk assessment. The actual presence of these indicator species or other species within the trophic guilds evaluated is uncertain. The actual area use of the indicator species is also unknown, and was conservatively assumed to be 100 percent.

The TRVs for the food chain models is another significant source of uncertainty. Values for both NOAELs and LOAELs can vary by up to four orders of magnitude. This is not unexpected as studies utilize different species, different chemical forms of a contaminant, different age

groups, different durations of exposure, and different exposure routes (e.g., gavage and drinking water), to name a few. Despite the availability of TRVs from numerous published studies, the NOAELs and LOAELs approved for use by Region 5 (which are primarily Region 9 NOAELs and LOAELs) and those identified by Sample et al. (1996) are values selected from single studies. In general, the NOAELs and LOAELs used for the food chain models (Table 5.9) are among the lowest values. Consequently, uncertainty associated with the NOAELs and LOAELs are biased toward conservatism. The discussion of the NOAEL and LOAEL for lead for avian wildlife presented below demonstrates both the uncertainty and conservatism associated with TRVs.

The NOAEL and LOAEL for lead for avian receptors are those identified by U.S. EPA, Region 9 (U.S. EPA 2009). The NOAEL of 0.014 mg/kg/day is identified as a study published in Toxicology and Applied Pharmacology by Edens et al. (1967). This value is uncertain for several reasons. This source could not be verified in the citation (Volume 38; pages 307-314) identified by U.S. EPA (2009). Volume 38 does not appear to have been published in 1967. The value of 0.014 mg/kg/day is an order of magnitude lower than the lowest NOAEL of 0.194 mg/kg/day used to develop the ECO-SSL for avian wildlife (U.S. EPA, 2005f). In addition, Edens et al. (1967) is not identified in the ECO-SSL source document as either a study that met the criteria for development of ECO-SSLs or was rejected as not meeting the criteria (see Appendix 5.1 in U.S. EPA, 2005f). As another line of evidence, use of 0.014 mg/kg/day as a TRV produces a soil concentration of 0.039 mg/kg for protection of American woodcock. The background concentration of lead for the Michigan Glacial Lobe reported by MDEQ (2005) is 7.4 mg/kg, which is two orders of magnitude greater than a NOAEL-based protective concentration of 0.039 mg/kg.

The LOAEL of 8.75 mg/kg/day identified by Region 9 (U.S. EPA, 2009) is based on a study by Edens and Garlich (1983) that reports the effects of lead on reproduction of chickens. As is the case for the NOAEL, the LOAEL for this study is also questionable based on several lines of evidence. The ECO-SSL source document for lead (U.S. EPA, 2005f) does present the results of a study by Edens and Garlich (1983) for chicken, as well as Japanese quail. The LOAELs summarized in Appendix 5.1 of ECO-SSL source document (U.S. EPA, 2005f) are 10 mg/kg diet and 50 mg/kg diet for Japanese quail and chicken, respectively. The converted dose values are 1.94 mg/kg/day and 3.26 mg/kg/day for Japanese quail and chicken, respectively. The LOAEL of 8.75 mg/kg/day identified by U.S. EPA (2009) does not match the converted doses for either Japanese quail or chicken identified in U.S. EPA (2005f).

Assuming the LOAEL of 8.75 mg/kg/day identified by Region 9 is based on Edens and Garlich (1983), the form of lead used in the study is one that is not present under field conditions. The form tested is lead acetate. As identified in Table 3 of Attachment 4.3 of the guidelines for

developing ECO-SSLs (U.S. EPA, 2007a), "No" is entered for lead acetate under the column heading "*could be found in the soil environment.*" Lead acetate has a relatively high solubility (1,600 µg/L), as calculated using U.S. EPA's EPI-Suite program (U.S. EPA, 2012). Furthermore, Jones (2013) documented that LOAELs based on lead acetate are statistically lower than forms of lead that are expected to occur in the soil environment.

One additional line of evidence of the uncertainty associated with a LOAEL of 8.75 mg/kg/day is that this value is lower than both the geometric mean (10.9 mg/kg/day) and median (12.3 mg/kg/day) for NOAELs for reproduction and growth identified in the ECO-SSL for lead (U.S. EPA, 2005f). The LOAEL of 8.75 mg/kg/day is in the lower 35th percentile of NOAELs for reproduction and growth.

Section 7.0 Ecological Preliminary Remediation Goals

7.1 Overview

The food chain models identified carbazole, HMW PAHs, cadmium, copper, lead, mercury, selenium, and zinc as potentially posing risk to avian and/or mammalian wildlife. To facilitate risk management decisions, ecological PRGs were developed for these eight COPECs. Ecological PRGs are 95 percent UCL concentrations of the eight COPECs in soil that are protective of avian and mammalian wildlife.

The exposure factors and assumptions for food chain models presented in Section 5.0 were intentionally conservative in order to minimize the probability of incorrectly dismissing the potential for risk. In contrast, the objective of ecological PRGs is to balance the protection of wildlife while avoiding unnecessary remedial measures.

7.2 Methodology

Many of the exposure parameters for the food chain models presented in Section 5.0 are conservative and intentionally overestimate the potential for risk. For example, the food ingestion rates of the indicator species (IR_{food}) are high end point estimates used to develop the ECO-SSLs (U.S. EPA, 2007a). Similarly, the P_s values for incidental soil ingestion are 90th percentile values (U.S. EPA, 2007a). These high-end estimates are intended for use in screening for COPECs and should not be used for the development of PRGs upon which risk management decisions are made.

For development of the ecological PRGs, exposure parameters and ingestion rates were taken from the U.S. EPA's Wildlife Scenario Builder (WSB) program (U.S. EPA, 2013b). In this program,

ingestion is based on the metabolic requirements of free ranging organisms [free metabolic rate expressed as kilocalories (kcal) per day] and assimilation efficiencies for the various dietary components. Whereas the food chain models in Section 5.0 assumed a single food item for an indicator species (e.g. American woodcock eats only soil invertebrates), the WSB identifies a number of dietary items for an indicator species, each with distinct values for gross energy (kilocalorie per gram) and assimilation efficiencies. Body weights to normalize ingestion are based on values in the program that have been vetted by U.S. EPA (U.S. EPA, 2013b). The result is a more ecologically realistic modeling of ingestion and exposure.

American woodcock and short-tailed shrew, both insectivores, were modeled using the WSB. As concentrations in soil invertebrates are higher than in terrestrial plants and small mammals (see Table 5.8), the potential for risk to insectivores is greater than for herbivores or carnivores. As demonstrated by the results of the food chain models, the HQs are higher for insectivores than herbivores or carnivores for all eight COPECs. Table 7.1 identifies the exposure parameters identified in the WSB program for American woodcock and short-tailed shrew. As a conservative measure, the 90th percentiles for incidental soil ingestion were retained.

Similar to the food chain models in Section 5.0, the WSB approach calculates ingestion COPECs as mg/kg-day. The calculated ingestion is then divided by a TRV to produce a HQ. For development of the ecological PRGs, the TRVs are the LOAELs used for the food chain models in Section 5.0.

As discussed in Section 6.0, there is a very high degree of conservatism and uncertainty associated with the LOAEL for lead for avian wildlife (8.75 mg/kg-day). Due to the conservatism associated with the LOAEL of 8.75 mg/kg-day, the PRG based on this LOAEL represents a lower end PRG for lead. To provide a range PRGs for lead, which is the primary risk driver for ecological receptors, an upper end PRG was also developed for avian wildlife based on a LOAEL of 42.7 mg/kg-day. The latter LOAEL is the geometric mean of the 15 bounded LOAELs (i.e., a paired NOAEL is reported) identified in the source document for the ECO-SSL for lead (U.S. EPA, 2005f). This LOAEL is conservative as it is within the range of NOAELs (approximate 80th percentile of NOAELs) and within the lower 30th percentile of bounded LOAELs (U.S. EPA, 2005f).

PRGs were developed for American woodcock and short-tailed shrew by back-calculating a soil concentration that produced a HQ of 1.0. The ecological PRG was the lower of the avian and mammalian PRGs. The ecological PRGs were compared to the 95 percent UCL concentrations of the COPECs. A 95 percent UCL greater than an ecological PRG identifies a need for risk management. Because wildlife forage at numerous feeding locations rather than a single

location, concentrations of a COPEC may exceed its PRG at some sample locations and still be protective of wildlife.

7.3 Comparison of Ecological Preliminary Remediation Goals to Exposure Concentrations

Table 7.2 identifies the PRGs for avian and mammalian wildlife and the ecological PRGs. As discussed in the previous section, the ecological PRG is the lower of the PRGs for avian and mammalian wildlife.

Table 7.3 summarizes the comparison of the 95 percent UCL concentrations of the COPECs to their ecological PRGs. Table 7.3 also identifies the 95 percent UCL concentrations expressed as a percent of the PRGs. The 95 percent exposure concentrations for carbazole, HMW PAHs, cadmium, copper, mercury, selenium, and zinc are below their ecological PRGs. For these seven COPECs, the 95 percent UCL is less than 50 percent of the PRG. This result indicates that concentrations of carbazole, HMW PAHs, cadmium, copper, mercury, selenium, and zinc in soil of the corridor of the Kalamazoo River are protective of avian and mammalian wildlife for these COPECs.

For lead, the lower end and upper range PRGs are 140 mg/kg and 812 mg/kg, respectively. The 95 percent UCL of 181 mg/kg exceeds the lower end PRG of 140 mg/kg and is below the upper end PRG of 812 mg/kg. The 95 percent UCL is 22 percent of the upper end PRG.

7.4 Risk Management Considerations

The PRGs identify lead as the only COPEC requiring a risk management decision, because the 95 percent UCL is within the range of the lower end and upper end PRGs. The maximum detected concentration of lead in the dataset for the refinement process is 990 mg/kg. Removal of this sample from the dataset reduces the 95 percent UCL from 181 mg/kg to 126 mg/kg, an exposure concentration below the lower end PRG of 140 mg/kg. This result triggers a decision whether or not measures for risk management should be undertaken.

One consideration for risk management is the degree of uncertainty and level of conservatism associated with the LOAELs upon which the lower end and upper end PRGs are based. As discussed in Section 6.0, there is a high degree of uncertainty and conservatism associated with the LOAEL of 8.75 mg/kg-day, including verification of the value. Moreover, the LOAEL of 8.75 mg/kg-day is subjective, as it is based on a single (unverified) study. The alternative LOAEL of 42.7 mg/kg-day is a conservative value based on multiple studies vetted by U.S. EPA in development of ECO-SSLs for lead (U.S. EPA, 2005f).

A risk management decision is beyond the scope of this document. That decision is the responsibility of the risk manager. The risk management decision will be based on the data and analyses presented in this document, as well as consideration of the net environmental benefits of potential remedial actions. Regardless of the risk management decision, the ecological risk assessment process will not continue to the remaining steps of the BERA.

Section 8.0 Complete Exposure Pathways and Ecosystems at Risk

8.1 Complete Exposure Pathways

The SLERA presented a Conceptual Site Model (CSM) that identified all potentially complete exposure pathways for ecological receptors. Although all the exposure pathways identified in the SLERA are potentially complete, the refinement step focused on exposure to avian and mammalian wildlife exposed to COPECs via ingestion of food and soil. The results of the refinement process and comparison of 95 percent UCL concentrations to ecological PRGs document that, although avian and mammalian wildlife are exposed to carbazole, HMW PAHs, cadmium, copper, mercury, selenium, and zinc in soil within the assessment area, the potential for risk for all receptors is below the threshold for concern. For lead, risk management will ensure that the potential for risk to ecological receptors is also below the threshold for concern.

8.2 Ecosystems at Risk

The assessment area for the refinement process is located within the riparian corridor of the Kalamazoo River. Based on the ecological PRGs for carbazole, HMW PAHs, cadmium, copper, mercury, selenium, and zinc, there are no known ecosystems at risk within the assessment area. For lead, risk management will ensure that the ecosystem of the Kalamazoo River corridor is not at risk.

Section 9.0 Selection of Assessment Endpoints

At this point in ecological risk assessment process, assessment endpoints for the BERA are selected. The assessment endpoints focus on those exposure pathways that are identified as complete and those constituents with concentrations that potentially pose risk to ecological receptors. As discussed in Section 7.0, the ecological risk assessment process is not advancing past the refinement process and development of ecological PRGs. Consequently, selection of assessment endpoints for the BERA is not required.

Section 10.0 Conceptual Site Model and Risk Questions

10.1 Conceptual Site Model

If the risk assessment process were to advance to the next steps of the BERA, the CSM would be revised to identify those exposure pathways and ecological receptors exposed to the constituents retained as COPECs. Because the risk assessment process is not advancing, revision of the CSM is not required.

10.2 Risk Questions

The ecological risk assessment process is not advancing past the refinement process and development of ecological PRGs. Therefore, development of risk hypotheses and questions is not required.

Section 11.0 Summary and Conclusions

Chemical constituents identified in the SLERA as COPECs were refined in accordance with U.S. EPA guidance for conducting ecological risk assessment (U.S. EPA, 1997). The refinement process is Step 3 of the 8-step process. Prior to refinement, the dataset used for the SLERA was modified by eliminating those samples collected from areas that are anticipated to be redeveloped, thus eliminating complete exposure pathways for ecological receptors. The revised dataset was then re-screened using the same methodology and ESVs as were used in the SLERA. The re-screening retained 2 VOCs (i.e., acetone and isopropylbenzene), 3 BTEX constituents (i.e., benzene, toluene, and m&p-xylene), 1 SVOC (i.e., carbazole), HMW PAHs, and 14 inorganic constituents [i.e., antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, vanadium, zinc, and cyanide (total)] as COPECs.

The refinement process focused on avian and mammalian wildlife. The constituents retained as COPECs were refined using a two phase process. In the first phase, 95 percent UCL concentrations, as calculated using ProUCL, Version 5.0 (U.S. EPA, 2013a), were compared to ecological benchmarks specific to avian and/or mammalian wildlife (RBs). Those constituents with 95 percent UCL concentrations greater than their RBs were carried forward to the second phase of the analysis. Those constituents that do not have a RB specific to avian and/or mammalian wildlife were also carried forward.

For the second phase of the refinement process, food chain models were used to evaluate the potential for risk to avian and mammalian wildlife. For lead, the food chain models identified a potential for risk to avian insectivores based on both the NOAEL and LOAEL. For mammalian

insectivores and carnivores, a potential for risk was identified for the NOAEL, but not the LOAEL. A potential for risk for one or more receptor groups was identified for carbazole, HMW PAHs, cadmium, copper, lead, mercury, selenium, and zinc to one or more receptor groups based on NOAELs, but not for LOAELs.

Ecological PRGs were developed for carbazole, HMW PAHs, cadmium, copper, lead, mercury, selenium, and zinc using food chain models and exposure parameters identified in the U.S. EPA's WSB (U.S. EPA, 2013b). The rationale is that the food chain models used for the refinement process include a number exposure parameters and assumptions that are overly conservative for development of PRGs, which trigger risk management if exceeded. The WSB methodology calculates ingestion of COPECs based on metabolic requirements of free ranging organisms and assimilation efficiencies for each dietary component. Whereas the food chain models for the refinement process assumed a single food item for an indicator species, the WSB identifies a number of dietary items for an indicator species.

LOAELs were used as the TRVs for development of the ecological PRGs. The LOAELs used in the refinement process were also used for the PRGs. As discussed in Section 6.0, there is a high degree of uncertainty and conservatism associated with the LOAEL for lead for avian wildlife. Due to the high level of conservatism, the PRG based on this LOEAL represents a lower end PRG. To provide an upper end value, a PRG was also developed for avian wildlife using a LOAEL based on the geometric mean of bounded LOAELs identified in the source document for the ECO-SSLs for lead (U.S. EPA, 2005f).

The 95 percent UCL of each COPEC was compared to its ecological PRG. For carbazole, HMW PAHs, cadmium, copper, mercury, selenium, and zinc, the 95 percent UCL concentration was below the ecological PRG. The 95 percent UCL concentrations were also less than 50 percent of the PRG for these seven COPECs. Consequently, it can be concluded that concentrations of carbazole, HMW PAHs, cadmium, copper, mercury, selenium, and zinc in soil within the corridor of the Kalamazoo River are protective of avian and mammalian wildlife and that risk management is not required to achieve RAOs.

For lead, the lower end PRG is greater than the 95 percent UCL whereas the upper end PRG is below the 95 percent UCL. Removal of the sample location with the highest concentration from the dataset reduces the 95 percent UCL concentration to a value below both the lower end and upper end PRGs. A risk management decision for lead will be made based on the data and analyses presented in this document as well as consideration of net environmental benefits of potential remedial actions.

The data and analyses presented in this document are sufficient for decisions to be made regarding the protection of ecological receptors within the corridor of the Kalamazoo River. Consequently, the ecological risk assessment process is not advancing to the next steps of the BERA.

Section 12.0 References

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